Draft Requirements for a
Fischer-Tropsch Single Battlespace Fuel
(Joint Battlespace Use Fuel of the Future or "JBUFF")

Introduction

Today's military uses JP-8/JP-5/Jet A-1 fuel as the Single Battlefield Fuel. This means that all equipment in the battlespace from generators to aircraft, armored vehicles to aircraft carriers must be capable of using the same fuel. There are currently some exceptions, however, to this requirement; some systems must still use other fuels. For example, RP-1 fuel is used for rockets and JP-7 for hypersonic vehicles. Even so, the goal to continuously move towards a "true" Single Battlespace Fuel is critical to the further, and very desirable, reduction in logistics footprint realized by supplying fewer fuels. Technological advances that will be introduced to the battlespace may make it increasingly difficult to realize the "true" Single Battlespace Fuel.

To make a Single Battlepsace Fuel a reality for the future, options other than petroleum-based fuels need to be explored. One such fuel is Fischer-Tropsch (FT) fuel. FT fuels would be excellent fuels for the reformers needed to make hydrogen for use in fuel cells, since they can be produced to have essentially no sulfur (a catalyst poison) and no aromatics to reduce reformer efficiency (coking). Such a fuel, free of heteroatoms and aromatics, may enable design of very advanced efficient aviation turbine engines. Furthermore, these same characteristics of FT fuels make them attractive for use in rockets and hypersonic vehicles, thus presenting the possibility of eliminating RP-1 and JP-7 fuels. The highly paraffinic nature of FT fuels results in high cetane values which also makes them attractive as fuels in compression-ignition engines.

Designating a FT Joint Battlespace Use Fuel of the Future

In considering the requirements for a FT Joint Battlespace Use Fuel of the Future, the goal would be to designate a fuel that could be used interchangeably with petroleum JP-8/JP-5 in existing equipment and that would be well-suited to the advanced propulsion and power systems planned for the future. So, this drives such a designation towards a fuel that, at point of manufacture, is essentially free of sulfur (or has very low sulfur) and other heteroatoms. As far as aromatics, the discussion is more complicated. As aromatics found in JP-8/JP-5 are known to swell certain types of sealants and elastomers used as seals in the fuel-wetted components of the military's existing equipment, introducing a FT JP-8/JP-5 type fuel that is free of aromatics presents the possibility of fuel leakage. On the other hand, having a FT JP-8/JP-5 fuel that is free of aromatics is desirable for the systems of the future. One approach is to designate a FT Joint Battlespace Use Fuel of the Future that is free of aromatics (or is very low aromatics). Such a fuel could be blended with conventional fuel to introduce the needed level of aromatics or a "seal swell additive" could be added to achieve the desired end-use effect.

Draft FT JBUFF Requirements

How to designate a FT Battlespace Use Fuel of the Future? Attached are draft of requirements for FT JBUFF. Note that these draft requirements are for a fuel at point of manufacture. Also note that these are only draft requirements (Version 1); we envision that this draft of requirements will continue to evolve, and therefore will remain as a "working draft", going through several revisions as we continue to dialog with various stakeholders.

We would like potential fuel manufacturers to consider these requirements based on their particular processes, either existing or anticipated, for manufacturing of the finished fuel from liquid hydrocarbons produced via Fischer-Tropsch synthesis and then upgrading those resultant hydrocarbons (or appropriate fraction of them) as needed. We would like other various stakeholders concerned with the designation and use of such a fuel to consider just what should be required to adequately define and test for the chemical and physical properties with respect to the intended use of the fuel.

Attachment

DRAFT REQUIREMENTS FOR
FISCHER-TROPSCH
JOINT BATTLESPACE USE FUEL OF THE FUTURE
(FT JBUFF)

-- This document is a draft of requirements for Fischer-Tropsch Joint Battlespace Use Fuel of the Future.

-- This document is a "working draft" for research and development purposes.

-- This data is not to be construed as binding in any way regarding acceptance of such a fuel for actual use or testing by the U.S. military.

1. REQUIREMENTS

1.1 Materials. The fuel supplied per this document shall be hydrocarbons derived from Fischer-Tropsch synthetic crude and containing additives in accordance with 1.3.

1.2 Chemical and physical requirements. The chemical and physical requirements of the finished fuel, at point of manufacture, shall conform to those listed in Section 1 and Table I.

1.3 Additives. The type and amount of each additive shall be made available when requested by the procurement activity or user.

1.3.1 Antioxidants. Immediately after processing and before fuel is exposed to the atmosphere, add an approved antioxidant (see 1.3.1.1) to prevent formation of peroxides after manufacture. The concentration of antioxidant to be added shall be not less than 17.2 mg nor more than 24.0 mg of active ingredient per liter of fuel (6.8 to 8.4 lb/1000 barrels).

1.3.1.1. Antioxidant formulations. The following antioxidant formulations are approved:

a. 2,6-di-tert-butyl-4-methylphenol
b. 6-tert-butyl-2,4-dimethylphenol
c. 2,6-di-tert-butylphenol
d. 75 percent min 2,6-di-tert-butylphenol and
   25 percent max tert-butylphenols and tri-tert-butylphenols
e. 72 percent min 6-tert-butyl-2,4-dimethylphenol and
   28 percent max tert-butyl-methylphenols and tert-butyl-dimethylphenols
f. 55 percent min 2,4-dimethyl-6-tert-butylphenol and
   15 percent min 2,6-di-tert-butyl-4-methylphenol and
   30 percent max mixed methyl and dimethyl tert-butylphenols

1.4 Workmanship. At the time of Government acceptance, the finished fuel shall be visually free from undissolved water, sediment, or suspended matter and shall be clear and bright. In case of dispute, the fuel shall be clear and bright at 21°C (70°F) and shall contain no more than 1.0 mg/L of particulate matter as indicated in Table I.

TABLE I. Chemical and physical requirements and test methods.

Property	Test Method ASTM[1]		FT JBUFF GRADES
APPEARANCE			
Saybolt color	**D 156** or D 6045		--
COMPOSITION			
Total acid number, mg KOH/g	D 3242	max	--
Aromatics, volume %	D 1319	max	report
Sulfur, mercaptan, mass %	D 3227	max	--
or Doctor test	D 4952		--
Sulfur, total, mass %	D 129[2], D 1266, D 2622, D 3120, **D 4294**, or D 5453	max	0.0015
JP-5		max	--
JP-8		max	--
VOLATILITY			
Distillation temperature D 86 (D 2887 in parentheses), °C:	**D 86**[3] or D 2887		
Initial boiling point			report
10% recovered		max	206 (185)
20% recovered			report
50% recovered			report
90% recovered			report
Final boiling point (end point)		max	300 (330)
Distillation residue, volume % [D 86]		max	1.5
Distillation loss, volume % [D 86]		max	1.5
Flash point, °C:	D 56, **D 93**, or D 3828		
JP-5 [FT JBUFF type "JP-5"]		min	60[4]
JP-8 [FT JBUFF type "JP-8"]		min	38[4]
Density at 15°C, kg/L (API max - min):	D 1298 or **D 4052**	min - max	0.751 - 0.845 (57.0 - 36.0)
JP-5		min - max	--
JP-8		min - max	--
FLUIDITY			
Freezing point, °C:	**D 2386**, D 5901, or D 5972		
JP-5 [FT JBUFF type "JP-5"]		max	-46
JP-8 [FT JBUFF type "JP-8"]		max	-47
Viscosity - 20°C, mm^2/s:	D 445		
JP-5 [FT JBUFF type "JP-5"]		max	8.5
JP-8 {FT JBUFF type "JP-8"]		max	8.0

TABLE I. Chemical and physical requirements and test methods. (continued)

Property	Test Method ASTM[1]		FT JBUFF GRADES
COMBUSTION			
Net heat of combustion, MJ/kg (specific energy)	D 3338, **D 4809**, or D 4529		--
JP-5		min	--
JP-8		min	--
Calculated Cetane Index	D 976[6]		report
Hydrogen content, mass %	D 3701	min	--
One of the following requirements shall be met:			
(1) Smoke point, mm	D 1322		--
JP-5		min	--
JP-8		min	--
OR for JP-8 only (2) Smoke point, mm AND	D 1322		--
Naphthalenes, volume %	D 1840	max	0.1
CORROSION			
Copper strip, 2 h at 100°C, rating or class	D 130	max	--
STABILITY			
Filter pressure drop, mm Hg	D 3241[7]	max	25
Tube deposit code	D 3241[7]	max	3[8]
CONTAMINANTS			
Existent gum, mg/100 mL	D 381[9]	max	--
Particulate matter, mg/L	D 2276[10] or **D 5452**[10]	max	1.0[11]
Filtration time, minutes	D 2276 or **D 5452**	max	--
Water reaction: Interface rating	D 1094	max	--
OTHER			
Micro-separometer ratings:	D 3948		
MSEP with AO[12], MDA[12]		min	--
MSEP with AO[12], MDA[12] and FSII[12]		min	--
MSEP with AO[12], MDA[12] and CI/LI		min	--
MSEP with AO[12], MDA[12], CI/LI and FSII		min	--
Fuel system icing inhibitor, volume %:	D 5006[13]	min - max	--
JP-5		min - max	--
JP-8		min - max	--
Electrical conductivity, pS/m:	D 2624	min - max	--
JP-5		min - max	--
JP-8		min - max	--

Notes: (see next page)

Notes:

[1] Referee method in bold.

[2] JP-8 grades only.

[3] A condenser temperature of 0°C to 4°C shall be used for the distillation.

[4] ASTM D 3828 may give results up to 1.7°C below the ASTM D 93 results. ASTM D 56 may give results up to 1°C below the ASTM D 93 results.

[5] When the fuel distillation test is performed using ASTM D 2887, the average distillation temperature, for use in ASTM D 3338 shall be calculated as follows: V=(10%+50%95%)/3

[6] Mid-boiling temperatures may be obtained by either D 86 or D 2887 to perform the Cetane Index calculation. If D 86 values are used, they should be corrected to standard barometric pressure.

[7] Conditions for ASTM D 3241: (1) heater tube temperature atm aximum point to be 260°C; (2) fuel system pressure to be 3.45 MPa; (3) fuel flow rate to be 3.0 mL/min.; and (4) testdu ration to be 150 minutes.

[8] Peacock or abnormal color deposits result in a failure.

[9] If air is used instead of steam while performing ASTM D 381, it must be reported. I n case of a failure with air, the sample must be retested using steam.

[10] A minimum sample size of 3.79 liters (1 gallon) shall be filtered. Filtration time will be determined in accordance with the procedure of Appendix A in MIL-DTL-5624U or MIL-DTL-83133E. This procedure may also be used for the determination of particulate matter as an alternate to ASTM D 2276 of ASTM D 5452.

[11] It muston ly be shown that the fuel meets the requirement in case of a dispute regarding workmanship, see 1.4.

[12] Even though the presence or absence of this additive does not change these limits, samples submitted for specification conformance testing shall contain the same additives present in the refinery batch. Regardless of which minimum the refiner elects to meet, the refiner shall report the MSEP rating on a laboratory hand blend of the fuel with all additives required by the specification.

[13] The DiEGME scale of the refractometer shall be used when completing this test.

[14] This is range of conductivity allowed at ambient fuel temperature or 29.4°C, whichever is lower.